METHOD AND DEVICE FOR DRIVING A PLASMA DISPLAY PANEL

BACKGROUND OF THE INVENTION

1. Field of the Invention

5   The present invention relates to a method for driving a plasma display panel (PDP).

Television sets having a large screen of a PDP is becoming commonplace. As a resolution of a screen increases, a load of a power source circuit for a PDP in a

10   display device becomes large. Therefore, countermeasures against the increasing load are requested.

2. Description of the Prior Art

An AC type PDP having three different fluorescent materials of different light emission colors is used for a

15   color display. In the AC type PDP, display electrodes for generating display discharge that determines light emission quantity of cells are covered with a dielectric layer, and wall voltage that is generated by electrification of the dielectric layer is utilized for

20   the display discharge. Among all cells within the screen, cells that are to generate display discharge are set to have higher wall voltage than other cells' wall voltage (usually zero volt). After that, a sustaining pulse train having amplitude lower than discharge start voltage is

25   applied to every cell similarly. When a sum of the amplitude of the sustaining pulse and the wall voltage exceeds the discharge start voltage, display discharge is generated. At this time, ultraviolet rays are generated by a discharge gas and excite fluorescent materials in

30   cells so as to emit light. The sustaining pulse is

applied for approximately a few microseconds, and the light emission looks continuous.

The application of the sustaining pulse train by the driving device is performed for all cells at the same time after a line-sequential addressing step in which wall voltage in each cell of the screen corresponds to display data. A waveform of a usual sustaining pulse has a simple rectangular shape. Responding to the application of the sustaining pulse, display discharge is generated in all cells to be lighted substantially at the same time. Accordingly, concentrated discharge current flows temporarily from the power source circuit of the driving device to the plasma display panel. This concentration of the discharge current may cause a drop in amplitude of the sustaining pulse, i.e., a voltage drop, thereby the display distortion is generated. A power source circuit that can supply a current large enough to avoid the voltage drop is expensive, and it is not realistic to use such a power source circuit in the driving device.

A driving method that can relieve the concentration of the discharge current is disclosed in Japanese unexamined patent publication No. 2001-34227. In the method the waveform of the sustaining pulse is made a trapezoidal shape having a gentle voltage change at a leading edge. Since there is a little variation in the discharge start voltage among cells, some cells are relatively easy to start discharge but other cells are hard. Responding to the application of the sustaining pulse, display discharge begins at cells having low discharge start voltage at first. After that, display

discharge begins at cells having high discharge start voltage. If the voltage change at leading edges of the sustaining pulse is gentle, a time point when display discharge begins in cells having high discharge start

5 voltage is delayed compared with the case where the voltage change at leading edges of the sustaining pulse is sharp. In other words, since a start timing of the display discharge is dispersed in the entire screen, the concentration of the discharge current is relieved. Also,

10 Japanese unexamined patent publication No. 2000-206928 discloses a method for dispersing the start timing of the discharge by making the waveform of the sustaining pulse be a step-like shape having a two-step voltage change at a leading edge of the sustaining pulse. Japanese unexamined

15 patent publication No. 6-4039 discloses a circuit structure for relieving the concentration of current by shifting application timing for each of plural blocks constituting the screen.

There are problems in the conventional driving

20 method. One of them is that power is consumed wastefully when the number of cells to be lighted is small and thus efficiency of light emission drops. Another problem is that ion bombardment received by the fluorescent material and the dielectric layer is larger when the number of

25 cells to be lighted is small compared to the case when the number of cells to be lighted is large. As explained above, the dispersion of the start timing of the display discharge can reduce a peak value (a maximum instantaneous value) of the discharge current. However, the peak value

30 of the discharge current is larger when the number of

cells to be lighted is large compared to the case when the number of cells to be lighted is small. In addition, the voltage drop is more conspicuous if the current flows more. Therefore, it is necessary to determine the amplitude of

5   the sustaining pulse in designing a drive condition in expectation of a voltage drop in the case where the number of cells to be lighted is large so that display discharge can be generated even if a voltage drop occurs. In this way, if the amplitude of the sustaining pulse is

10   determined on the basis of the case where the number of cells to be lighted is large, voltage higher than necessary is applied to cells when the number of cells to be lighted is small. As a result, excessive display discharge occurs, efficiency of light emission drops, and

15   cells may receive excessive ion bombardment.

Related Patent Publication 1:

    Japanese unexamined patent publication No. 2001-34227

Related Patent Publication 2:

    Japanese unexamined patent publication No. 2000-206928

20   Related Patent Publication 3:

    Japanese unexamined patent publication No. 6-4039

SUMMARY OF THE INVENTION

    An object of the present invention is to reduce

25   wasteful power consumption and to reduce ion bombardment that can deteriorate cells so that cells can have a long life.

    According to the present invention, a ratio of lighting that is a ratio of the number of cells to be

30   lighted to the total sum number of cells is detected in

accordance with display data that determine contents of
addressing. In accordance with the detected ratio of
lighting, a waveform of a voltage pulse that is applied in
the sustaining step for displaying the corresponding

5 display data is changed so that a gradient of the voltage
change at a leading edge becomes smaller for a large value
of the ratio of lighting than for a small value of the
same. By applying the voltage pulse having a gentle
leading edge, a variation in discharge characteristics

10 among cells is utilized for dispersing display discharge
of plural cells in time scale. The dispersion of display
discharge relieves concentration of discharge current and
reduces a peak value of the discharge current. In
addition, the leading edge of the voltage pulse is made

15 gentler for a larger value of the ratio of lighting, so
that the peak value of the discharge current when the
ratio of lighting is large becomes substantially the same
as the peak value of the discharge current when the ratio
of lighting is small. This equalization of the peak value

20 makes the change of the voltage drop small in the output
of the power source due to the change of ratio of lighting.
In other words, the voltage drop in the output of the
power source becomes substantially constant regardless of
the ratio of lighting. Therefore, excessive display

25 discharge is not generated even if a voltage pulse having
amplitude is applied to cells when the ratio of lighting
is small, the amplitude being the same as when the ratio
of lighting is large. The change of the pulse waveform
can be a step-by-step change in which the ratio of

30 lighting is classified into plural ranges and different

settings are made for the ranges or can be a continuous change in which different settings are made for values of the ratio of lighting. Furthermore, when adopting a circuit structure in which a screen is divided into plural

5 blocks and application of the pulse is controlled for each of the blocks, the waveform of the pulse may be changed for each of the blocks.

BRIEF DESCRIPTION OF THE DRAWINGS

10   Fig. 1 is a block diagram of a display device according to the present invention.

      Fig. 2 is a schematic diagram of an X-driver and a Y-driver.

      Fig. 3 is a perspective diagram showing an example

15 of a cell structure in a PDP.

      Fig. 4 is a conceptual diagram of frame division.

      Fig. 5 is a diagrammatic chart of drive voltage waveforms.

      Fig. 6 is a diagrammatic chart of switching of a

20 sustaining pulse waveform in a first example.

      Fig. 7 is a diagrammatic chart showing effects of switching the sustaining pulse waveform in the first example.

      Fig. 8 is a schematic diagram of a sustain circuit.

25   Fig. 9 is a timing chart showing a switch control of the sustaining pulse waveform.

      Fig. 10 is a diagrammatic chart of switching of the sustaining pulse waveform in a second example.

      Fig. 11 is a diagrammatic chart showing effects of

30 switching the sustaining pulse waveform in the second

example.

Fig. 12 is a block diagram of a display device in which drive control is performed in a screen division format.

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DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinafter, the present invention will be explained more in detail with reference to embodiments and drawings.

Fig. 1 is a block diagram of a display device
10 according to the present invention. The display device 100 includes a surface discharge AC type PDP 1 having a color screen 88 and a drive unit 70 for controlling light emission of cells. The display device 100 is used as a wall-hung television set or a monitor display of a
15 computer system.

The PDP 1 includes electrode pairs for generating display discharge each of which includes a display electrode X and a display electrode Y arranged in parallel, and address electrodes A arranged so as to cross the
20 display electrodes X and Y. The display electrodes X and Y extend in the row direction (in the horizontal direction) of the screen 88, while the address electrodes extend in the column direction (in the vertical direction).

The drive unit 70 includes a controller 71, a data
25 conversion circuit 72, a power source circuit 73, a state detection circuit 74, an X-driver 75, a Y-driver 76 and an A-driver 77. The drive unit 70 is supplied with frame data Df that indicate luminance levels of red, green and blue colors from an external device such as a TV tuner or
30 a computer together with various synchronizing signals.

The frame data Df are stored in a frame memory of the data conversion circuit 72 temporarily. The data conversion circuit 72 converts the frame data Df into sub frame data Dsf for a gradation display and sends the sub frame data

5   Dsf to the A-driver 77. The sub frame data Dsf is a set of display data in which one bit corresponds to one cell, and a value of each bit indicates whether the cell is lighted or not in the corresponding sub frame, more specifically, whether address discharge is necessary or

10   not. The A-driver 77 applies an address pulse to an address electrode A that is connected to cells in which the address discharge is generated in accordance with the sub frame data Dsf. An application of a pulse to an electrode means to bias the electrode to a predetermined

15   potential temporarily. The controller 71 controls applications of the pulse and transmission of the sub frame data Dsf. The power source circuit 73 supplies the drivers with electric power necessary for driving the PDP 1.

20   The state detection circuit 74 includes a portion 74A for detecting a "ratio of display load" in each frame and a portion 74B for detecting a "ratio of lighting" in each sub frame, the ratio of lighting being unique to the present invention. The ratio of display load is an index

25   of power consumption and is defined as an average value of all discharge cells having the ratio G_i/G_{max} when a gradation value of a cell in one frame is G_i ($0 \leqq G_i \leqq G_{max}$). This ratio of display load is used for an auto power control (APC) for reducing the application of the

30   sustaining pulse when displaying a bright image so as to

suppress power consumption and heat generation. On the
other hand, the ratio of lighting is a ratio of the number
k of cells to be lighted in a sub frame to the total
number K of all cells (e.g., as a percentage the ratio of

5   lighting = k/K x 100) and is an index of a voltage drop in
the sustaining step. The state detection circuit 74
counts the number of bits indicating cells to be lighted
in accordance with the sub frame data Dsf so as to detect
the ratio of lighting and inform the controller 71 of the

10   detected ratio of lighting. The ratio of lighting is used
for changing and setting the waveform of the sustaining
pulse.

　　　Fig. 2 is a schematic diagram of an X-driver and a
Y-driver. The X-driver 75 includes a reset circuit 81 for

15   applying a pulse for initializing wall charge to the
display electrode X, a bias circuit 82 for controlling
potential of the display electrode X in the addressing
step for generating wall charge in cells to be lighted and
a sustain circuit 83 for applying a sustaining pulse to

20   the display electrode X in the sustaining step for
generating display discharge in cells to be lighted, the
number of times of display discharge corresponding to
display data. The Y-driver 76 includes a reset circuit 85
for applying a pulse for initializing wall charge to the

25   display electrode Y, a scan circuit 86 for applying a scan
pulse to the display electrode Y in the addressing step
and a sustain circuit 87 for applying a sustaining pulse
to the display electrode Y in the sustaining step. The
bias circuit 82 in the X-driver 75 and the scan circuit 86

30   in the Y-driver 76 structure means for realizing the

addressing step along with the controller 71, the data
conversion circuit 72 and the A-driver 77. The sustain
circuit 83 in the X-driver 75 and the sustain circuit 87
in the Y-driver 76 structure means for realizing the
5   sustaining step along with the controller 71.

      Fig. 3 is a perspective diagram showing an example
of a cell structure in a PDP. In Fig. 3, a part
corresponding to three cells for one pixel display of the
PDP 1 is illustrated with a pair of substrate structural
10   bodies 10 and 20 separated so that the inner structure can
be seen. The PDP 1 has a pair of substrate structural
bodies 10 and 20. The substrate structural body means a
structural body including a glass substrate and other
elements such as electrodes arranged on the glass
15   substrate. In the PDP 1, the inner surface of the front
glass substrate 11 is provided with the display electrodes
X and Y, the dielectric layer 17 and the protection film
18, while the inner surface of the back glass substrate 21
is provided with the address electrodes A, the insulator
20   layer 24, partitions 29 and fluorescent material layers
28R, 28G and 28B. Each of the display electrodes X and Y
includes a transparent conductive film 41 for forming a
surface discharge gap and a metal film 42 as a bus
conductive member. The partitions 29 are arranged so that
25   one partition corresponds to one electrode gap of the
address electrode arrangement, and these partitions 29
divide the discharge space in the row direction into
column spaces. The column space 31 corresponding to each
column in the discharge space is continuous over all rows.
30   The fluorescent material layers 28R, 28G and 28B are

excited locally by ultraviolet rays emitted by the discharge gas and emit light. Italic letters R, G and B in Fig. 3 indicate light emission colors of the fluorescent materials.

5   A general driving sequence of the PDP 1 in the above-mentioned display device 100 is as follows. In the display of the PDP 1, reproduction of colors is realized by binary control of lighting. Therefore, each of the sequential frames F constituting an input image is divided

10   into a predetermined number q of sub frames SF as shown in Fig. 4. In other words, each of the frames F is replaced with a set of q sub frames SF. These sub frames SF are assigned weights, e.g., 2^0, 2^1, 2^2, ..., 2^{q-1} in turn, so that the number of times of display discharge is

15   determined for each sub frame SF. Though the sub frame arrangement is in the order of weights in Fig. 7, it can be in other order. In accordance with this frame structure, the frame period Tf that is a frame transmission period is divided into q sub frame periods

20   Tsf, and one sub frame period Tsf is assigned to each of the sub frames SF. In addition, the sub frame period Tsf is divided into a reset period TR for initializing wall charge, an address period TA for the addressing step and a display period TS for the sustaining step. The lengths of

25   the reset period TR and the address period TA are constant regardless of the weight, while the length of the display period TS is longer for larger weight. Therefore, the length of the sub frame period Tsf is also longer as the weight of the corresponding sub frame SF is larger. In

30   the q sub frames SF, the order of the reset period TR, the

address period TA and the display period TS is common.
The initialization of wall charge, the addressing step and
the sustaining step are performed for each sub frame.

Fig. 5 is a diagrammatic chart of drive voltage

5 waveforms. In Fig. 5, the suffix (1, n) of the reference
numeral of the display electrode Y indicates the
arrangement order of the corresponding row. The
illustrated waveforms are one example, and the amplitude,
the polarity and the timing can be changed variously.

10   In the reset period TR of each sub frame, ramp
waveform pulses having the negative polarity and the
positive polarity are applied sequentially to all display
electrodes X, and ramp waveform pulses having the positive
polarity and the negative polarity are applied

15 sequentially to all display electrodes Y so that
increasing voltage is applied between the display
electrodes of all cells. The amplitude of these ramp
waveform pulses increase at a sufficiently small rate such
that micro discharge is generated. The cells are supplied

20 with combined voltage that is a total sum of the amplitude
of pulses that are applied to the display electrodes X and
Y. The micro discharge generated by the first application
of the increasing voltage makes all cells generate
appropriate wall voltage in the same polarity regardless

25 of the lighted or non-lighted in the previous sub frame.
The micro discharge generated by the second application of
the increasing voltage adjusts the wall voltage to a value
corresponding to the difference between the discharge
start voltage and the amplitude of the applied voltage.

30   In the address period TA, wall charge that is

necessary for the sustaining step is formed only in the cells to be lighted. While all display electrodes X and all display electrodes Y are biased to a predetermined potential, a scan pulse Py is applied to one display

5   electrode Y corresponding to the selected row every row selection period (every scanning time of one row). At the same time with this row selection, an address pulse Pa is applied only to the address electrodes A corresponding to selected cells in which address discharge is generated.

10   In other words, in accordance with the sub frame data Dsf of m columns of the selected row, potential of the address electrode A is controlled in a binary manner. In the selected cell, discharge is generated between the display electrode Y and the address electrode A, and the discharge

15   causes surface discharge between display electrodes. This series of discharge is address discharge.

In the display period TS, a sustaining pulse Ps is applied to the display electrode Y and the display electrode X alternately. Thus, a sustaining pulse train

20   having alternating polarities is applied between display electrodes. The application of the sustaining pulse Ps causes surface discharge in cells having predetermined quantity of remaining wall charge. The number of times of applying the sustaining pulse corresponds to the weight of

25   the sub frame as explained above. Furthermore, as shown in the example, the address electrode A can be biased in the same polarity as the sustaining pulse Ps during the display period TS so that undesired discharge is suppressed.

30   Among the above-explained driving sequence,

application of the sustaining pulse Ps in the display period TS has a strong connection to the present invention. It is important that the waveform of the sustaining pulse Ps is not fixed but is changed in accordance with the

5   ratio of lighting.

Fig. 6 is a diagrammatic chart of switching of a sustaining pulse waveform in a first example. In the illustrated example, the ratio of lighting is classified into three ranges, i.e., 0-40%, 41-60% and 61-100%, and

10   waveforms of sustaining pulses Ps_L, Ps_M and Ps_H are determined for each range. Among these sustaining pulses Ps_L, Ps_M and Ps_H, the gentleness of the voltage change at the leading edge, i.e., the lengths of the voltage increasing periods T11, T12 and T13 are different. The

15   relationship among the lengths is T11 < T12 < T13. The amplitude (i.e., the difference between the base potential of the pulse and the bias potential) Vs is common to the sustaining pulses Ps_L, Ps_M and Ps_H. The waveform of the sustaining pulse Ps_L when the ratio of lighting is within

20   the range of 0-40% has a rectangular shape and the leading edge thereof is sharp. The waveform of the sustaining pulse Ps_M when the ratio of lighting is within the range of 41-60% has a trapezoid shape and the leading edge thereof is a little gentle. The waveform of the

25   sustaining pulse Ps_H when the ratio of lighting is within the range of 61-100% has a trapezoid shape and the leading edge thereof is gentle. In other words, the voltage change at the leading edge of the waveform is more gentle when the ratio of lighting is large than when it is small.

30   Fig. 7 shows effects of switching the sustaining

pulse waveform in the first example. Here, cells are classified into three groups for convenience. It is supposed that generation of discharge is relatively easy in cells of a first cell group, it is harder in cells of a

5   second cell group than in cells of a first cell group, and it is harder in cells of a third cell group than in cells of a second cell group. For example, when the ratio of lighting is 20%, display discharge is generated in response to the application of the sustaining pulse Ps_L in

10   cells to be lighted substantially simultaneously though there is a little difference among the first cell group, the second cell group and the third cell group. As a result, discharge current flows in a concentrated manner at one time. However, since the number of cells to be

15   lighted is relatively small, a peak value of the discharge current is not excessive. Furthermore, when the ratio of lighting is 80%, display discharge is generated in response to the application of the sustaining pulse Ps_H in cells to be lighted that belong to the first cell group,

20   the second cell group and the third cell group, in this order. Since the number of cells to be lighted is relatively large, an integral value of the discharge current is large. However, since the display discharge is dispersed in the time scale, the peak value of the

25   discharge current is not excessive in this case, either. As shown with a dot-dashed line in Fig. 7, if the sustaining pulse Ps_L is applied instead of the sustaining pulse Ps_H, the peak value of the discharge current will be excessive.

30   Next, a circuit structure for realizing switching of

the waveform of the sustaining pulse will be explained in focus on the application of the sustaining pulse to the display electrode X. The application of the sustaining pulse to the display electrode Y is similar to the

5 application of the sustaining pulse to the display electrode X, so explanation thereof is omitted.

Fig. 8 is a schematic diagram of a sustain circuit. The sustain circuit 83 is a switching circuit having a push-pull structure for outputting a pulse having an

10 amplitude Vs. The sustain circuit 83 includes a power collecting circuit 833 for reusing charge that was used for charging a capacitance between display electrodes. When one of three field-effect transistors Q11, Q12 and Q13, all of which are connected in parallel, is turned on,

15 the power source terminal of potential Vs is connected to the display electrode X via a backflow preventing diode D1. The field-effect transistors Q11, Q12 and Q13 are pull-up switches that bias the display electrodes X to the potential Vs. When the field-effect transistor Q20 is

20 turned on, the ground terminal is connected to the display electrode X via a backflow preventing diode D2. The field-effect transistor Q20 is a pull-down switch that sets the potential of the display electrode X to the pulse base potential. The field-effect transistors Q11, Q12,

25 Q13 and Q20 are operated in accordance with control signals SQ11, SQ12, SQ13 and SQ20 from the controller 71. The control signals SQ11, SQ12, SQ13 and SQ20 are transmitted to the field-effect transistors Q11, Q12, Q13 and Q20 through gate drivers.

30 Fig. 9 is a timing chart showing a switch control of

the sustaining pulse waveform. As illustrated, when the ratio of lighting is within the range of 0-40%, three field-effect transistors Q11, Q12 and Q13 are turned on in the application of the sustaining pulse Ps_L. In contrast,

5   when the ratio of lighting is within the range of 41-60%, two field-effect transistors Q11 and Q12 are turned on in the application of the sustaining pulse Ps_M. Further, when the ratio of lighting is within the range of 61-100%, only one field-effect transistor Q11 is turned on in the

10   application of the sustaining pulse Ps_H. The smaller the number of transistors that are turned on, the larger the impedance of the current path between the power source terminal and the display electrode X, and the smaller the current that flows into the capacitance between the

15   display electrodes. The smaller the current is, the gentler the applied voltage increases.

As another method for switching the voltage change at the leading edge of the pulse, there is a method of turning on the pull-up switch intermittently at a short

20   period that is changed. There is still another method in which plural current paths that can be open or close and have different impedances including a capacitance or a resistance and a transistor are disposed between the pull-up switch and the display electrode X, and the plural

25   current paths are closed selectively.

Fig. 10 is a diagrammatic chart of switching of the sustaining pulse waveform in a second example. In this second example too, the ratio of lighting is classified into three ranges of 0-40%, 41-60% and 61-100%, and

30   waveforms of the sustaining pulses Ps_L, Ps_M and Ps_H are

determined for each range. The waveforms of the
sustaining pulses Ps_L, Ps_M and Ps_H have a step-like shape
in which the voltage changes in a step-like manner at a
leading edge. Among these sustaining pulses Ps_L, Ps_M and

5   Ps_H, lengths of mid-potential retaining periods T21, T22
and T23 for retaining a bias of potential Vs' (Vs' < Vs)
at a midpoint of the voltage change in the leading edge
are different from each other. The relationship among
the lengths is T21 < T22 < T23. Since the amplitude Vs is

10   common to the sustaining pulses Ps_L, Ps_M and Ps_H, a period
for changing voltage is logically longer and the voltage
change at the leading edge is gentler when the mid-
potential retaining periods T21, T22 and T23 are longer.
Namely, the second example also utilizes a waveform having

15   a voltage change at the leading edge that is milder when
the ratio of lighting is large than when it is small, in
the same way as the first example shown in Fig. 6.

Generation of the step-like waveform and switching
of the lengths of the periods T21, T22 and T23 are

20   realized by two power sources and a switching circuit that
controls conduction between each of the power sources and
the display electrode. First the path between the power
source terminal of the potential Vs' and the display
electrode is closed so as to start the application of the

25   pulse, and the conducting state is kept until the period
T21, T22 or T23 passes. Then, the path between the power
source terminal of the potential Vs and the display
electrode is closed. After that, the path between the
ground terminal and the display electrode is closed so as

30   to finish the application of the pulse.

Fig. 11 is a diagrammatic chart showing effects of switching the sustaining pulse waveform in the second example. In the second example too, the same effect is obtained as in the first example. For example, when the

5 ratio of lighting is 20%, display discharge is generated in response to the application of the sustaining pulse Ps_L in cells to be lighted substantially simultaneously though there is a little difference among the first cell group, the second cell group and the third cell group. As a

10 result, discharge current flows in a concentrated manner at one time. However, since the number of cells to be lighted is relatively small, a peak value of the discharge current is not excessive. Furthermore, when the ratio of lighting is 80%, display discharge is generated in

15 response to the application of the sustaining pulse Ps_H in cells to be lighted that belong to the first cell group, the second cell group and the third cell group, in this order. Since the number of cells to be lighted is relatively large, an integral value of the discharge

20 current is large. However, since the display discharge is dispersed in the time scale, the peak value of the discharge current is not excessive in this case, either. As shown with a dot-dashed line in Fig. 11, if the sustaining pulse Ps_L is applied instead of the sustaining

25 pulse Ps_H, the peak value of the discharge current will be excessive.

In the embodiment explained above, it is possible to include a function of detecting a drop of the sustaining voltage due to display discharge and adjusting the

30 amplitude Vs not to be lower than a minimum permissible

value. The stepwise voltage change of the step-like
waveform is not limited to two steps but can be three or
more steps. When the voltage change is performed in three
or more steps, the length of two or more steps at a
5   midpoint may be adjusted so as to disperse the discharge
timing.

       As the embodiment of the present invention, an
example is explained in which the sustaining pulse Ps
having a single polarity is applied to the display
10   electrodes X and Y alternately. However, another driving
form can be adopted in which pulses of the positive
polarity and the negative polarity and having the
amplitude of Vs/2 are applied to the display electrodes X
and Y simultaneously so as to apply the sustaining voltage
15   Vs between the display electrodes. Concerning the
arrangement of the display electrodes X and Y, it is not
limited to the arrangement in which a pair of them
corresponds to a row of the matrix display, but can be an
arrangement in which the display electrodes of the number
20   of rows n plus one are arranged at a constant pitch so
that three electrodes correspond to two rows. The present
invention can be applied to any arrangement form.

       Referring to a display device 200 in Fig. 12, if
adopting a circuit structure in which a screen is divided
25   into plural blocks 89A and 89B and pulse application is
controlled for each block, a detailed driving control can
be performed in which the ratio of lighting is determined
for each block and the waveform of the pulse is changed in
accordance with the result. If the screen is divided so
30   that one or more rows constitute a block in accordance

with the arrangement of the display electrodes X and Y and a driver is disposed for each of the blocks, the waveform of the pulse can be controlled for each block.

The display device 200 includes a surface discharge
5   AC type PDP 2 and a drive unit 90. The structure of the PDP 2 is the same as that of the PDP 1 mentioned above with the exception that the display electrodes X are connected to each other for each block. The drive unit 90 includes a controller 91, a data conversion circuit 92, a
10 power source circuit 93, a state detection circuit 94, X-drivers 95A and 95B, Y-drivers 96A and 96B and an A-driver 97. The state detection circuit 94 includes a portion 94A for detecting a display load ratio of each of the blocks 89A and 89B in each frame and a portion 94B for detecting
15 a lighting ratio of each of the blocks 89A and 89B in each sub frame. The X-driver 95A and the Y-driver 96A take charge of drive of the block 89A, while the X-driver 95B and the Y-driver 96B take charge of drive of the block 89B.

According to the present invention, wasteful power
20 consumption can be reduced when the number of cells to be lighted is small, and ion bombardment that may deteriorate cells can be suppressed so as to realize a long life of cells.

While the presently preferred embodiments of the
25 present invention have been shown and described, it will be understood that the present invention is not limited thereto, and that various changes and modifications may be made by those skilled in the art without departing from the scope of the invention as set forth in the appended
30 claims.